

N93-31440

FUZZY CONTROL/SPACE STATION AUTOMATION

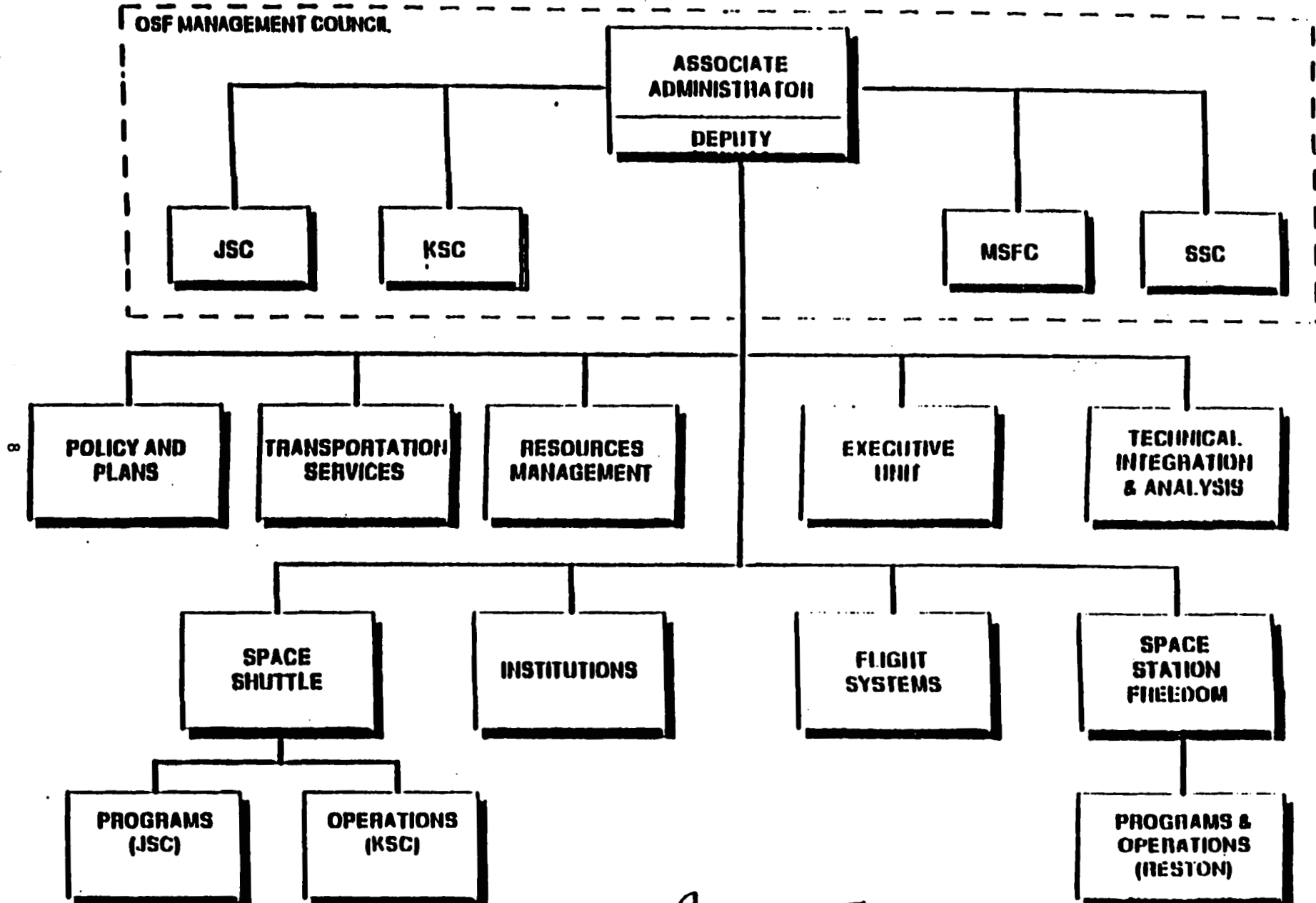
by

**Mark Gersh
NASA Headquarters**

14 November 1990

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Office of Space Flight



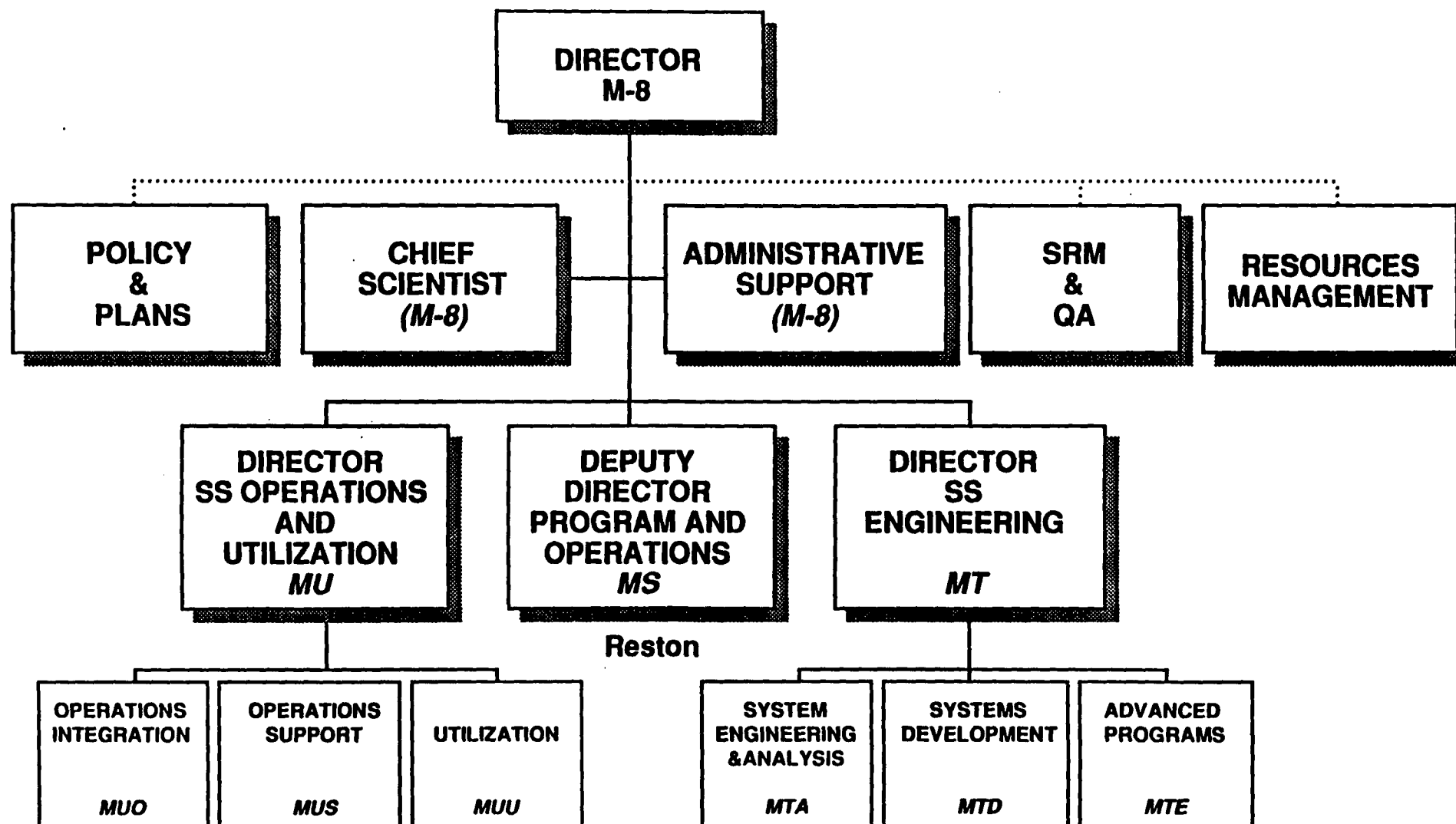
Approved

Date

Richard F. ...
Feb. 9 1969



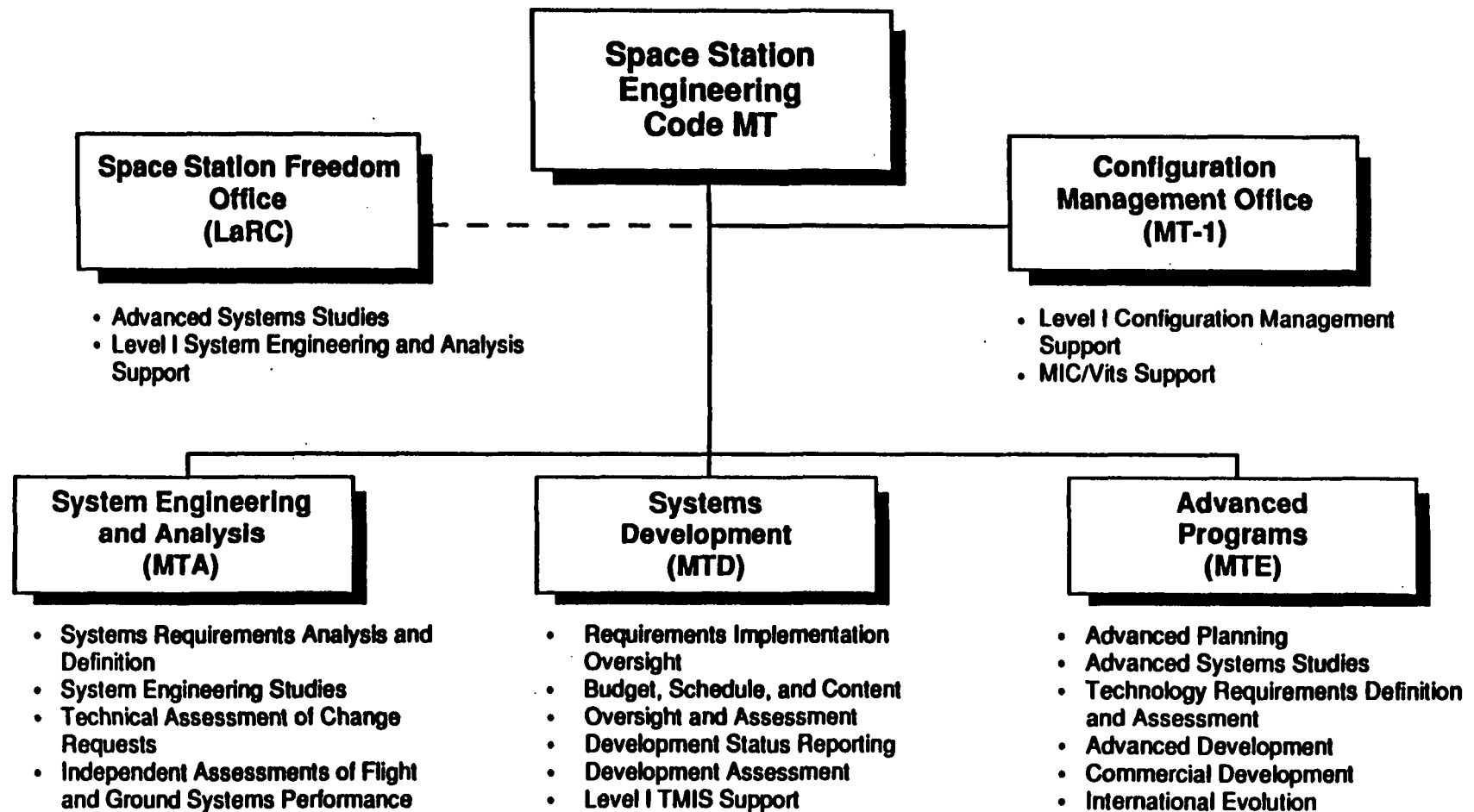
OFFICE OF SPACE FLIGHT SPACE STATION FREEDOM



Code MT Organization and Responsibilities

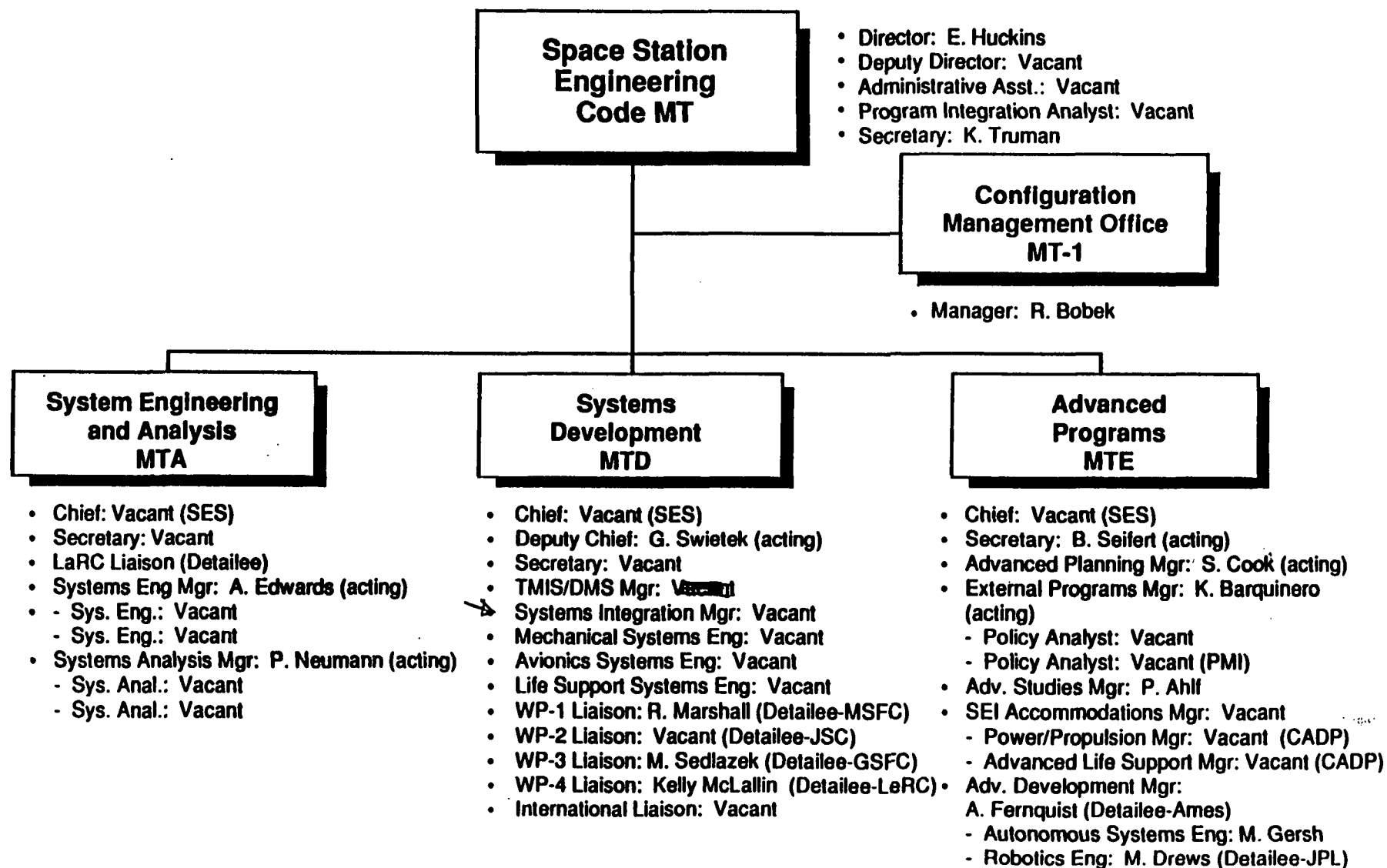
Space Station Engineering Organization

FREEDOM





Code MT Staffing



SPACE STATION FREEDOM

FREEDOM



Objectives

- **Provide a permanently manned presence in space**
- **Enhance capabilities for space science and applications**
- **Stimulate advanced technologies**
- **Promote international cooperation**
- **Encourage private sector participation and utilization**
- **Provide options for future endeavors in space**

SPACE STATION FREEDOM

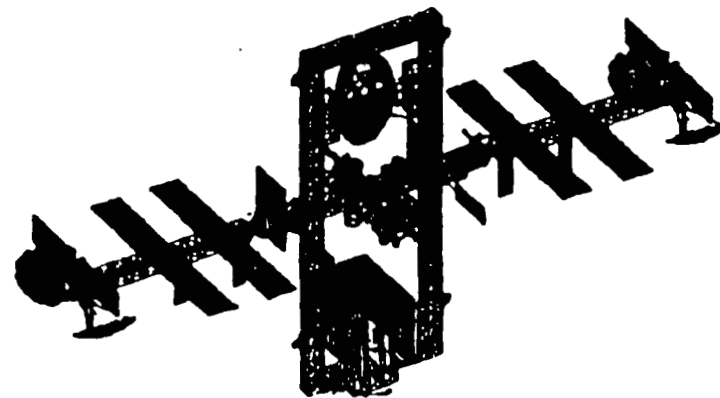
Evolution



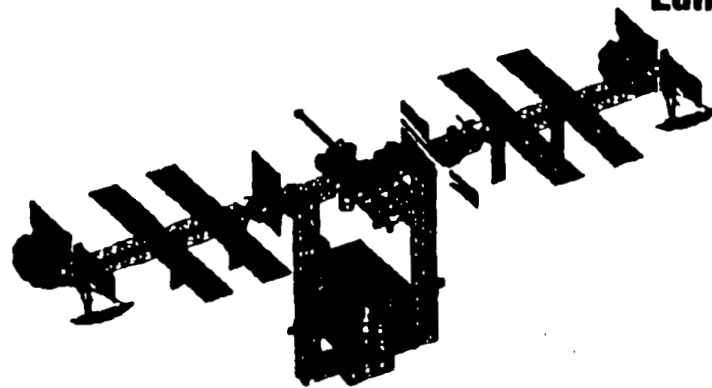
- **Freedom is a permanent facility:**
 - **Upgrades and configuration changes will take place on-orbit**

- **During the operational life of the Space Station:**
 - **National priorities will change**
 - **User needs and mission requirements will change**
 - **Technology will evolve and components will become obsolete**

SPACE STATION FREEDOM EVOLUTION FOR HUMAN EXPLORATION



Lunar & Mars Operations



Lunar Vehicle Operations



Assembly Complete

SPACE STATION FREEDOM

Factors Pointing to Automation & Robotics (A&R)

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- **Space Station has a 30 year operational life**
 - **Operations costs, reliability are important concerns**
 - **Incorporation of new technology essential**
- **Crew is most scarce resource**
 - **Productivity is crucial in meeting assembly, user, and servicing requirements**
- **Evolution mission scenarios are crew-intensive**
 - **Science missions will grow and increase demand for crew time**
 - **On-orbit assembly, checkout, launch of Lunar/Mars vehicles**

SPACE STATION FREEDOM

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The A&R Promise

- **Increased Mission Safety, Reliability**
 - **Manage system complexity**
 - **Trend analysis, fault detection, isolation, and reconfiguration**
 - **Reduce EVA required**
- **Increased Mission Productivity, Services**
 - **Reduce "housekeeping" overhead**
 - **Reduce experiment overhead**
- **Increased Probability of Mission Success**
 - **Re-planning for contingencies, reactive science**
- **Reduced Operations Costs**
 - **Training, software maintenance, sustaining engineering**

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Astronaut Office Inputs Concerning A&R



- **Regarding Advanced Automation**
 - **Simple, standardized human interface (idiot proof)**
 - **Provide flexible operations capability**
 - **User (versus technology developer) oriented**
 - **Develop and implement easier applications first**
 - **Help the user do the job easier (don't make it harder)**
 - **Include "What if?" Capability (In-line simulation)**
 - **Backup mode of operation**
 - **System must be able to explain conclusions and actions**
- **Automate tedious and repetitive tasks, time dependent tasks, calibration and alignment tasks, robotic set-up for EVA**

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Astronaut Office Inputs Concerning A&R



- **Applications supported by crew for improving productivity:**
 - **Automated record keeping and documentation (100%)**
 - **Automated inventory management (96%)**
 - **Automated FDIR (93%)**
 - **Improved human-computer interfaces (92%)**
 - **Robotic construction (92%)**
 - **Exception reporting and alarm filtering (88%)**
 - **External camera and light pointing (87%)**
 - **Robotic external repairs (85%)**
 - **Automated trend analysis (incipient failure detection) (85%)**
 - **Checklist automation (85%)**

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Astronaut Office Inputs Concerning A&R

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- **Applications supported by crew for improving productivity:**
 - **Systems Monitoring and Control (82%)**
 - **EVA retriever robotics (81%)**
 - **Payload-specific automation (79%)**
 - **On-board training systems (72%)**
 - **Internal camera and lighting pointing (58%)**
 - **Speech Recognition (56%)**
 - **Speech Synthesis (54%)**
 - **On-board scheduling/re-scheduling capability (52%)**
 - **IVA rack robot (50%)**
 - **IVA housekeeping robot (46%)**

SPACE STATION FREEDOM

Advanced Development Program

FREEDOM



- **Objectives**
 - **Enhanced baseline Space Station Freedom capabilities**
 - **Improve productivity and reliability**
 - **Reduce operations costs**
 - **Prevent technological obsolescence**
 - **Enable Space Station Freedom evolution**
- **Products**
 - **"Engineering" fidelity demonstrations, evaluations**
 - **Detailed requirements, performance specifications**
 - **Mature technology, tools, applications**

SPACE STATION FREEDOM

Flight System Automation and Ground Operations Applications



- **Focused on Automated Status Monitoring, Fault Detection, Isolation, and Recovery (FDIR) using Knowledge-Based System (KBS) techniques**
- **Understand design accommodations ("hooks and scars")**
 - **Instrumentation, control redundancy, interfaces**
- **Identify KBS implementation issues**
 - **Integration with conventional techniques**
 - **Processing, data storage, communication requirements**
 - **Software development, testing, maintenance**
 - **Boundaries of KBS technology (performance, scale, brittleness)**
- **Applications under development for Thermal, Power, Life Support, Data Management, Mission Control**

SPACE STATION FREEDOM
Transition Definition Program
Advanced Development - FY 1990



- **Flight Systems and Ground Operations Automation Tasks**
 - **Focused on automated status monitoring, fault detection, isolation, and recovery (FDIR) using Knowledge-Based System (KBS) techniques**
 - **FDIR KBS applications under development for the Thermal Control System, Power Management and Distribution/Control Systems, Environmental Control and Life Support System, Data Management System, Operations Management System, Mission Control Center (MCC), and the Space Station Control Center (SSCC)**
 - **MCC applications were jointly developed with OAST and OSF and have supported STS-26, STS-29, STS-30, STS-28, STS-34 and STS-32; all will be transitioned to SSCC**

SPACE STATION FREEDOM

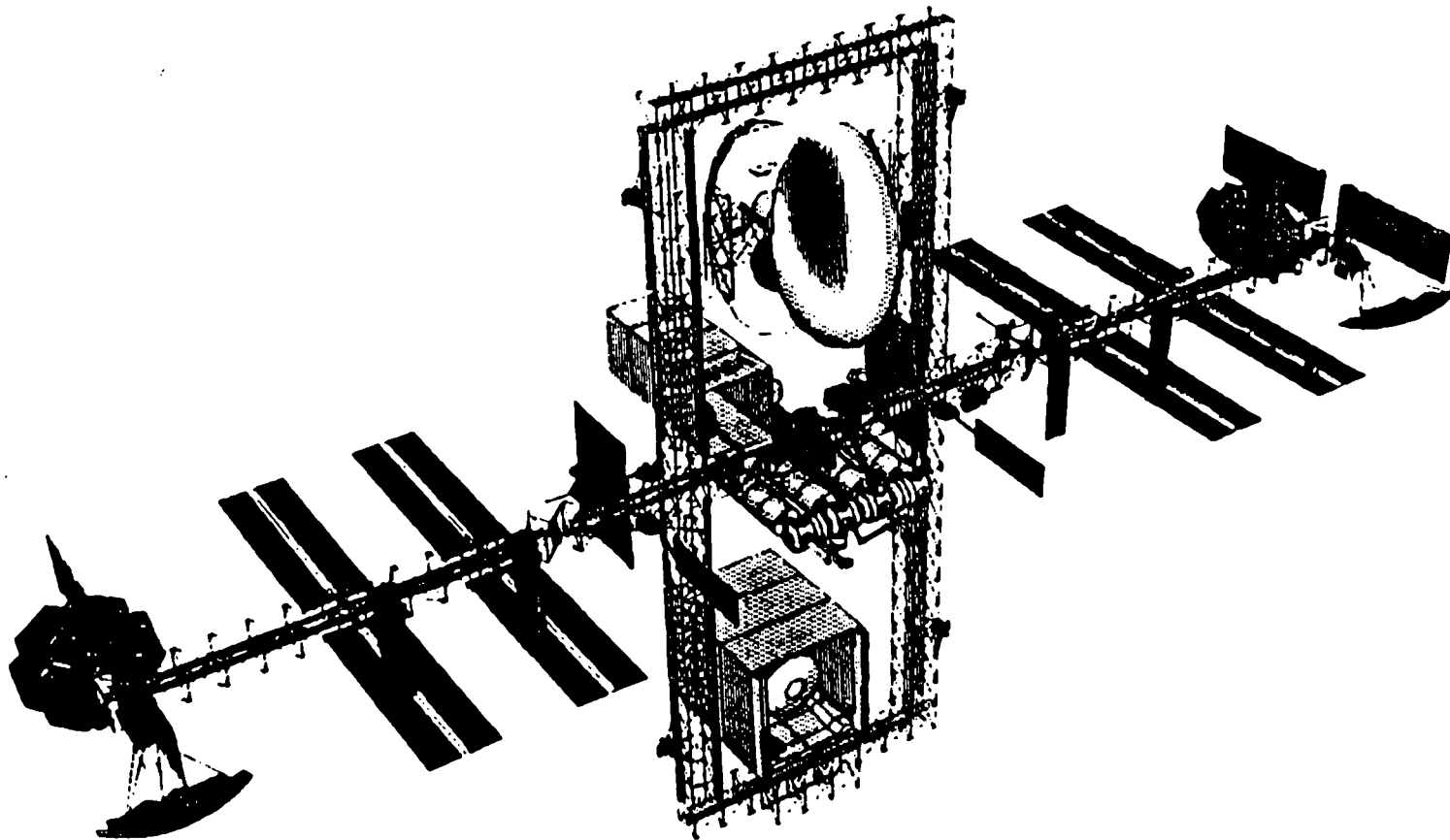
Advanced Automation Software Tools

FREEDOM



- **Focused on providing programming tools to enable development of integrated KBS applications within the Software Support Environment (SSE)**
 - **KBS programming tools which produce Ada code are under development and evaluation**
- **Develop and demonstrate advanced programming tools which reduce the cost of software development and maintenance for flight and ground systems**
 - **"Programmers Assistant" that uses KBS techniques to aid programmers in Ada software re-use under evaluation**
 - **Programming environment for Intelligent Computer-Aided Training (ICAT) applications under development**

LUNAR/MARS TRANSPORTATION NODE



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Some General Thoughts on Technology Transition

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- **In an ideal world, technology transition happens when...**
 - **The user is interested and involved in application development**
 - **The application and technology are consistent with operations concepts, procedures, and doctrine**
 - **Implementation is compatible with existing hardware and software and isolated ("firewalled") during initial evaluation period**
 - **"Success" metrics are defined early and guaranteed at some minimal level**
 - **"Bottoms up" and "top down" pressure is simultaneous and consistent**
 - **Post deployment "care and feeding" issues are addressed early**

SPACE STATION FREEDOM

Some General Thoughts on Technology Transition

FREEDOM



- **It's not an ideal world...**
 - **Organizational structure creates, encourages insular and myopic view of technology insertion opportunities and operational realities**
 - **Ego and fear of the unknown tends to reinforce status quo**
 - **Personnel and financial resources are limiting factors**
 - **Risk and schedule pressure are harsh realities**

SPACE STATION FREEDOM

Summary



- **Automation is a key element in meeting Space Station Freedom baseline and evolution requirements**
- **Automation technology is sufficiently mature to warrant early use within the Program**
- **Scope and pace of automation applications will be determined by:**
 - **Success of early testbed prototypes**
 - **Support and acceptance of managers and users**
 - **Consistent implementation methodology and tools**
- **"Technology transfer is a body contact sport." - John Muratore, JSC**
 - **People are a key factor in affecting or preventing technology transfer and utilization**